

Written Reply

To Mr. Junya GOTO, Examiner at the Patent Office

1. Identification of the International Application

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5. Contents of this Argument

- (1) The Examiner considers that claims 1 to 9 of the present application lack an inventive step.

In view of the Examiner's consideration, the Applicant filed a Written Amendment to amend the claims in the present application on the same date of this Written Reply. We believe that this amendment will lead to an acknowledgment that the present invention has an inventive step.

(2) Claims 3 and 4 are amended in the Written Amendment. Amended claim 3 is directed to the invention that has been defined in original claim 4. Amended claim 4 restricts amended claim 3 as follows: "a connecting portion between the sensor signal substrate and the cable substrate that is covered with the sensor ground substrate or the relay ground substrate" is "the entire connecting portion." It is disclosed on page 14, lines 17 to 18 (page 15, lines 13 to 15 of the English translation) of the specification as originally filed that the connecting portion is covered entirely. Claim 5 is amended so as to depend on "claim 1 or 4" instead of "claim 1."

(3) Inventive step of the invention according to amended claim 4

(i) Description of the present invention

As described in the Written Amendment, the invention of the present application is defined as follows.

"1. An ultrasonic probe, comprising: an ultrasonic element for transmitting and receiving an ultrasonic signal; a signal line for transmitting an electric signal to or from the ultrasonic element; and a ground line for supplying a ground potential to the ultrasonic element, the ultrasonic probe further comprising:

a sensor signal substrate and a sensor ground substrate connected electrically with the ultrasonic element; and

a cable substrate for electrically connecting the sensor signal substrate and the sensor ground substrate with the signal line and the ground line, respectively,

wherein the sensor ground substrate and the cable substrate are connected directly or via a relay ground substrate, and

at least a part of the cable substrate is covered with the sensor ground substrate or the relay ground substrate.

2. The ultrasonic probe according to claim 1, wherein at least a part of the sensor signal substrate is covered with the sensor ground substrate or the

relay ground substrate.

3. (Amended) The ultrasonic probe according to claim 1, wherein a connecting portion between the sensor signal substrate and the cable substrate is covered with the sensor ground substrate or the relay ground substrate.
4. (Amended) The ultrasonic probe according to claim 3, wherein the connecting portion between the sensor signal substrate and the cable substrate is covered with the sensor ground substrate or the relay ground substrate entirely.
5. (Amended) The ultrasonic probe according to claim 1 or 4, wherein at least a part of the ultrasonic element is covered with the sensor ground substrate or the relay ground substrate.
6. The ultrasonic probe according to claim 5, wherein an ultrasonic wave transmitting/receiving surface of the ultrasonic element is covered with the sensor ground substrate or the relay ground substrate.
7. The ultrasonic probe according to claim 6, wherein the ultrasonic wave transmitting/receiving surface and peripheral surfaces of the ultrasonic element are covered with the sensor ground substrate or the relay ground substrate.
8. The ultrasonic probe according to claim 6, wherein a plurality of grooves are formed on a part of the sensor ground substrate or the relay ground substrate that covers the ultrasonic wave transmitting/receiving surface of the ultrasonic element, the grooves dividing the ultrasonic element electrically into a plurality of oscillators.
9. The ultrasonic probe according to claim 6,
wherein the sensor ground substrate is arranged so as to surround a periphery of the ultrasonic element, the sensor signal substrate, and the cable substrate, and
a portion of the sensor ground substrate that is drawn over a surface of the ultrasonic element other than a surface connected with the sensor

signal substrate is connected with the cable substrate or a part of the sensor ground substrate.”

As mentioned above, amended claim 4 makes it clear that “at least a part of the cable substrate covered with the sensor ground substrate or the relay ground substrate” as recited in claim 1 is “the connecting portion between the sensor signal substrate and the cable substrate, and is the entire connecting portion.”

According to the invention described in amended claim 4, the sensor ground substrate and the cable substrate are connected directly or via the relay ground substrate. Therefore, unlike the case where these substrates are connected via a connector, it is possible to avoid an increase in resistance due to limitations on the number of connector poles, resulting in a reduction in ground resistance between the sensor ground substrate and the cable substrate. Consequently, the reduction in ground resistance suppresses a change in ground potential due to a noise current induced by extraneous electromagnetic waves. As a result, an adverse effect on a reception signal due to the change in ground potential is reduced, and image noise can be prevented from being caused.

Further, the connecting portion between the sensor signal substrate and the cable substrate is covered with the sensor ground substrate or the relay ground substrate entirely. Thus, the sensor ground substrate or the relay ground substrate can function as a shield for shielding the entire connecting portion. Therefore, it is possible to suppress noise from being caused due to extraneous electromagnetic waves, and the ultrasonic probe exhibits increased durability to withstand electromagnetic waves.

(ii) Description of cited documents

Document 1 (microfilm on which contents of the specification and the drawings attached to the application of Japanese Utility Model

Application No. 63-69188 are recorded) discloses an ultrasonic probe including a ground electrode and a signal electrode, wherein the ground electrode is connected with a ground wire via a third electrode (Figure 2 etc.).

However, Document 1 does not describe that the respective electrodes are connected by using a substrate. As shown in the present specification as originally filed (page 2, lines 18 to 26 (page 2, line 25 to page 3, line 4 of the English translation)) or the drawing (Figure 5), the present invention has been made in view of the problem that image noise is caused when a ground electrode of the ultrasonic element 203 is connected with the ground line 209b through the sensor connector 217 as well as the cable connector 218 and the cable substrate 208. It is considered that the cause of this problem is the use of flexible substrates such as the sensor ground substrate, the sensor signal substrate, and the cable substrate, which require the above-mentioned connectors. In order to avoid this problem, in the present invention, the sensor ground substrate and the cable substrate are connected directly or via the relay ground substrate with no connector provided therebetween, even in the case where the flexible substrates are used. In this manner, image noise is suppressed from being caused. On the other hand, the invention in Document 1 relates to an ultrasonic probe using a substrate electrode and a signal electrode instead of flexible substrates, and Document 1 neither describes nor suggests the problem caused by using a plurality of connectors for the connection and means for avoiding this problem. Even assuming that it is a well-known technique to use flexible substrates for drawing cables, Document 1 neither describes nor suggests that the use of flexible substrates require a plurality of connectors, which result in image noise. Further, there is neither description nor suggestion about the solution to this problem, that is, the configuration in which "the sensor ground substrate and the cable substrate are connected directly or via the relay ground substrate."

In addition, Document 1 neither describes nor suggests the configuration in which the connecting portion between the cable substrate and the sensor signal substrate (corresponding to the above-mentioned signal electrode) is covered with the sensor ground substrate (corresponding to the above-mentioned ground electrode) or the relay ground substrate entirely. More specifically, Document 1 discloses in Figure 2(1) that a first electrode 11b, a third electrode 7b, and a lead wire 5a are connected and drawn from one end portion of a piezoelectric element 10 and that a second electrode 12b and a lead wire 6a are connected and drawn from the other end portion of the piezoelectric element 10. However, it is not shown in Figure 2 that these leads become close to each other. Further, these leads are arranged in parallel with each other at a distance approximately equal to the width of the piezoelectric element 10, which makes it impossible to realize the configuration in which the sensor ground substrate or the relay ground substrate covers “the connecting portion between the sensor signal substrate and the cable substrate entirely.” Even assuming that a ground electrode (first electrode) 11 in Document 1 corresponds to the sensor ground substrate and a third electrode 7a corresponds to the relay ground substrate as indicated by the Examiner, the configuration of the present invention cannot be realized. The reason for this is as follows: the lead wire 5a corresponding to the sensor ground substrate and a lead wire 5b corresponding to the sensor signal substrate are drawn from different directions. Therefore, according to the description in Document 1, it is impossible for the sensor ground substrate or the relay ground substrate to cover the sensor signal substrate (connecting portion between the sensor signal substrate and the cable substrate) provided in a different direction from that of the sensor ground substrate or the relay ground substrate. As described above, Document 1 does not disclose the configuration of the present invention, and accordingly does not describe or suggest the effect of this configuration.

Document 2 (JP 2001-54194 A) discloses an ultrasonic probe in which an oscillator and cables (the signal line and the ground line) are connected by using a substrate (Figure 2 etc.). However, Document 2 does not refer to a specific configuration of the substrate used between the oscillator and the cables. In other words, it is not described that the oscillator is connected with the sensor signal substrate and the sensor ground substrate, and these substrates are connected with the signal line and the ground line, respectively, via the cable substrate. In addition, there is neither description nor suggestion about the configuration in which the connecting portion between the sensor signal substrate and the cable substrate is covered with the sensor ground substrate or the relay ground substrate entirely.

Document 3 (JP 2002-52024 A) and Document 4 (JP 1-291846) describe that cables are drawn by using flexible substrates. However, as Document 2, these documents neither describe nor suggest the configuration in which an oscillator is connected with the sensor signal substrate and the sensor ground substrate, and these substrates are connected with the signal line and the ground line, respectively, via the cable substrate and the configuration in which the connecting portion between the sensor signal substrate and the cable substrate is covered with the sensor ground substrate or the relay ground substrate entirely.

(iii) Comparison between the present invention and the inventions of the cited documents

As described above, Documents 1 to 4 neither describe nor suggest the configuration in which the sensor signal substrate and the sensor ground substrate are connected with the signal line and the ground line, respectively, via the cable substrate, the problem due to connectors, the configuration for avoiding this problem in which “the sensor ground substrate and the cable substrate are connected directly or via the relay

ground substrate."

Further, none of the documents describes or suggests the configuration of the present invention in which the connecting portion between the sensor signal substrate and the cable substrate is covered with the sensor ground substrate or the relay ground substrate entirely and the effect of this configuration.

Therefore, the present invention provides a particular configuration that is obviously different from that described in each of the above documents. With this particular configuration, image noise can be suppressed from being caused in the present invention. Further, the sensor ground substrate or the relay ground substrate can function as a shield for shielding the entire connecting portion between the sensor signal substrate and the cable substrate. Therefore, it is possible to suppress noise from being caused due to extraneous electromagnetic waves, and the ultrasonic probe exhibits increased durability to withstand electromagnetic waves. In this manner, the present invention can achieve a special effect, which cannot be achieved by the invention described in each of the above documents.

Therefore, we believe that the present invention is not obvious from the above documents and involves in an inventive step.

(4) The inventions according to claims 5 to 9 restrict the invention according to claim 4 further. Since the invention according to claim 4 has an inventive step over the above documents as described above, claims 5 to 9 would also have an inventive step.

(5) As described above, we believe that the present invention has an inventive step. We respectfully hope for the Examiner to consider that the present invention involves in an inventive step after due reexamination of the present application.

6. List of appended documents

(1) Written Amendment 1 set